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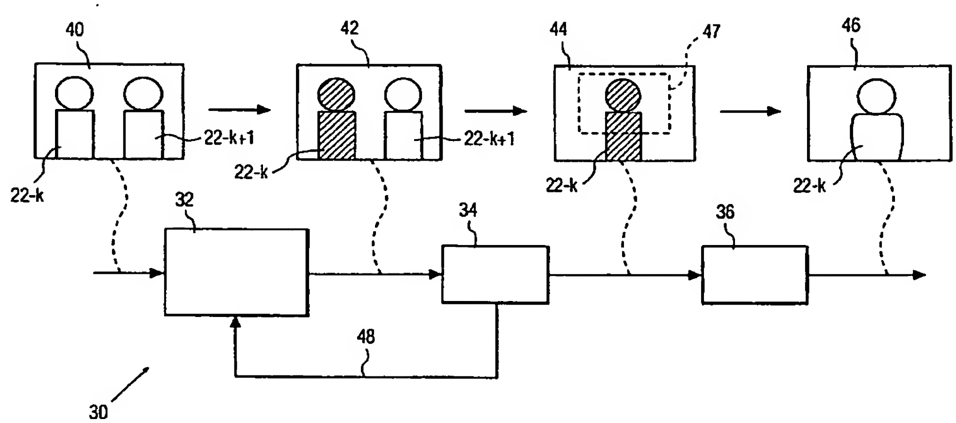
(54) Title: REAL-TIME TRACKING OF AN OBJECT OF INTEREST USING A HYBRID OPTICAL AND VIRTUAL ZOOMING MECHANISM



(57) Abstract: A video processing system tracks an object of interest using a hybrid combination of (i) optical zooming by a pan-tilt-zoom (PTZ) camera, and (ii) virtual zooming on an image generated by that camera. The object of interest (22-*k*) is initially detected in an image (40) generated by the camera (18). An optical zooming operation (34) then adjusts pan and tilt settings to frame the object of interest (22-*k*), and zooms in on the object of interest (22-*k*) until one or more designated stopping criteria are met. A virtual zooming operation (36) processes the resulting optically-zoomed image (44) to identify and extract a particular region of interest (47), and then interpolates the extracted region of interest to generate a virtually-zoomed image (46). The designated stopping criteria may indicate, e.g., that the optical zooming continues until the object of interest (22-*k*) occupies a fixed or dynamic percentage of the resulting optically-zoomed image.

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Real-time tracking of an object of interest using a hybrid optical and virtual zooming mechanism.

The present invention relates generally to the field of video signal processing, and more particularly to techniques for tracking persons or other objects of interest using a video camera such that a desired video output can be achieved.

Tracking a person or other object of interest is an important aspect of video-camera-based systems such as video conferencing systems and video surveillance systems. For example, in a video conferencing system, it is often desirable to frame the head and shoulders of a particular conference participant in the resultant output video signal, while in a video surveillance system, it may be desirable to frame the entire body of, e.g., a person entering or leaving a restricted area monitored by the system.

Such systems generally utilize one of two distinct approaches to implement tracking of an object of interest. The first approach uses a pan-tilt-zoom (PTZ) camera that allows the system to position and optically zoom the camera to perform the tracking task. A problem with this approach is that, in some cases, the tracking mechanism is not sufficiently robust to sudden changes in the position of the object of interest. This may be due to the fact that the camera is often being zoomed-in too far to react to the sudden changes. For example, it is not uncommon in a video conferencing system for participants to move within their seats, e.g., to lean forward or backward, or to one side or the other. If a PTZ camera is zoomed-in too far on a particular participant, a relatively small movement of the participant may cause the PTZ camera to lose track of that participant, necessitating zoom-out and re-track operations that will be distracting to a viewer of the resultant output video signal.

The second approach is referred to as Avirtual zoom≅ or Aelectronic zoom.≅ In this approach, video information from one or more cameras is processed electronically such that the object of interest remains visible in a desired configuration in the output video signal despite the fact that the object may not be centered in the field of view of any particular camera. U.S. Patent No. 5,187,574 discloses an example of such an approach, in which an image of an arriving guest is picked up by a fixed television camera of a surveillance system. The image is processed using detection, extraction and interpolation operations to ensure that the head of the guest is always displayed at the center of the monitor screen. This approach ensures that the video output has a desired form, e.g., is centered on an object of interest,

without the need for pan, tilt or zoom operations. As a result, this approach can operate with fixed cameras, which are generally significantly less expensive than the above-noted PTZ cameras. However, this approach fails to provide the output image quality required in many applications. For example, the extraction and interpolation operations associated with virtual zooming will generally result in a decreased resolution and image quality in the resultant output video signal, and therefore may not be suitable for video conferencing or other similar applications.

As is apparent from the above, a need exists for an improved tracking technique which can provide the output video signal quality and resolution associated with the PTZ camera approach as well as the flexibility of the virtual zoom approach, while also avoiding the problems generally associated with these approaches.

The invention provides methods and apparatus for real-time tracking of an object of interest in a video processing system, using a hybrid combination of (i) optical zooming by a pan-tilt-zoom (PTZ) camera, and (ii) virtual zooming on an image generated by that camera. In an illustrative embodiment of the invention, the object of interest is initially detected in an image generated by the camera. An optical zooming operation then adjusts pan and tilt settings to frame the object of interest, and zooms in on the object of interest until one or more designated stopping criteria are met. A virtual zooming operation processes the resulting optically-zoomed image to identify and extract a particular region of interest, and then interpolates the extracted region of interest to generate a virtually-zoomed image.

In accordance with one aspect of the invention, the designated stopping criteria may indicate, e.g., that the optical zooming continues until the object of interest occupies a fixed or dynamic percentage of the resulting optically-zoomed image. In the case of a dynamic percentage, the percentage may vary as a function of a detected quality associated with the object of interest. Examples of such detected qualities include a level of apparent motion, a use of a particular audibly-detectable key word or other cue, and a change in intensity, pitch or other voice quality.

In accordance with another aspect of the invention, the virtual zooming operation may be repeated on the resulting optically-zoomed image, using the same pan, tilt and zoom settings established in the optical zooming operation, if a level of movement of the object of interest exceeds a first designated threshold. The optical zooming operation itself may be repeated in order to establish new pan, tilt and zoom settings for the camera if the level of movement of the object of interest exceeds a second designated threshold higher than the first threshold.

The hybrid optical and virtual zoom mechanism of the invention provides a number of significant advantages over conventional approaches. For example, the hybrid mechanism accommodates a certain amount of movement of the object of interest without the need to determine new optical pan, tilt and zoom settings, while also providing a desired output image quality level. By preventing the PTZ camera from zooming in too far, the invention ensures that the PTZ camera settings are adjusted less frequently, and the computational load on the system processor is thereby reduced relative to that required by a conventional optical zoom approach. In addition, the hybrid mechanism of the invention can provide an improved compression rate for image transmission. These and other features and advantages of the present invention will become more apparent from the accompanying drawings and the following detailed description.

Fig. 1 is a block diagram of a video processing system in accordance with an illustrative embodiment of the invention.

Fig. 2 is a functional block diagram illustrating hybrid real-time tracking video processing operations implemented in the system of Fig. 1.

Fig. 1 shows a video processing system 10 in accordance with an illustrative embodiment of the invention. The system 10 includes a processor 12, a memory 14, an input/output (I/O) device 15 and a controller 16, all connected to communicate over a system bus 17. The system 10 further includes a pan-tilt-zoom (PTZ) camera 18 which is coupled to the controller 16 as shown. In the illustrative embodiment, the PTZ camera 18 is employed in a video conferencing application in which a table 20 accommodates a number of conference participants 22-1, ..., 22-*k*, ..., 22-N. In operation, the PTZ camera 18, as directed by the controller 16 in accordance with instructions received from the processor 12, tracks an object of interest which in this example application corresponds to a particular participant 22-*k*. The PTZ performs this real-time tracking function using a hybrid optical and virtual zooming mechanism to be described in greater detail below in conjunction with Fig. 2.

Although the invention will be illustrated in the context of a video conferencing application, it should be understood that the video processing system 10 can be used in a wide variety of other applications. For example, the portion 24 of the system 10 can be used in video surveillance applications, and in other types of video conferencing applications, e.g., in applications involving congress-like seating arrangements, circular or rectangular table arrangements, etc. More generally, the portion 24 of system 10 can be used in any application which can benefit from the improved tracking function provided by a hybrid optical and virtual zoom mechanism. The portion 26 of the system 10 may therefore be replaced with,

e.g., other video conferencing arrangements, video surveillance arrangements, or any other arrangement of one or more objects of interest to be tracked using the portion 24 of the system 10. It will also be apparent that the invention can be used with image capture devices other than PTZ cameras. The term Acamera≅ as used herein is therefore intended to include any type of image capture device which can be used in conjunction with a hybrid optical and virtual zooming mechanism.

It should be noted that elements or groups of elements of the system 10 may represent corresponding elements of an otherwise conventional desktop or portable computer, as well as portions or combinations of these and other processing devices. Moreover, in other embodiments of the invention, some or all of the functions of the processor 12 , controller 16 or other elements of the system 10 may be combined into a single device. For example, one or more of the elements of system 10 may be implemented as an application specific integrated circuit (ASIC) or circuit card to be incorporated into a computer, television, set-top box or other processing device. The term Aprocessor≅ as used herein is intended to include a microprocessor, central processing unit, microcontroller or any other data processing element that may be utilized in a given data processing device. In addition, it should be noted that the memory 14 may represent an electronic memory, an optical or magnetic disk-based memory, a tape-based memory, as well as combinations or portions of these and other types of storage devices.

Fig. 2 is a functional block diagram illustrating a hybrid optical and virtual zoom mechanism 30 implemented in the system 10 of Fig. 1. Again, although illustrated in the context of a video conferencing application, it will be apparent that the techniques described are readily applicable to any other tracking application. As shown in Fig. 2, the hybrid optical and virtual zoom mechanism 30 includes a detection and tracking operation 32, an optical zooming operation 34, and a virtual zooming operation 36. These operations will be described with reference to images 40, 42, 44 and 46 which correspond to images generated for the exemplary video conferencing application in portion 26 of system 10. The operations 32, 34 and 36 may be implemented in system 10 by processor 12 and controller 16, utilizing one or more software programs stored in the memory 14 or accessible via the I/O device 15 from a local or remote storage device.

In operation, PTZ camera 18 generates image 40 which includes an object of interest, i.e., video conference participant 22-*k*, and an additional object, i.e., another participant 22-*k*+1 adjacent to the object of interest. The image 40 is supplied as a video input

to the detection and tracking operation 32, which detects and tracks the object of interest 22-*k* using well-known conventional detection and tracking techniques.

For example, in the video conferencing application, the object of interest 22-*k* may correspond to the current speaker. In this case, the detection and tracking operation 32 may detect and track the object of interest 22-*k* using techniques such as audio location to determine which conference participant is the current speaker, motion detection to determine which conference participant is talking, gesturing, shaking his or her head, moving in a particular manner, speaking in a particular manner, etc.

In a video surveillance application, the object of interest may be a person taking a particular action, e.g., entering or leaving a restricted area or engaging in suspicious behavior, a child moving about in a room of a home, a vehicle entering or leaving a parking garage, etc. The output of the detection and tracking operation 32 includes information identifying the particular object of interest 22-*k*, which is shown as shaded in the image 42.

The particular type of detection and tracking mechanisms used in operation 32 will generally vary depending upon the application. Conventional detection and tracking techniques which may be used in operation 32 include those described in, e.g., C. Wren, A. Azarbayejani, T. Darrell, A. Pentland. APfinder: Real-time Tracking of the Human Body,≅ IEEE Trans. PAMI, 19(7):780-785, July 1997; H. Rowley, S. Bluja, T. Kanade, ARotation Invariant Neural Network-Based Face Detection,≅ Proc. IEEE Conf. on Computer Vision, pp.38-44, June 1998; and A. Lipton, H. Fujiyoshi, R. Patil, AMoving Target Classification and Tracking from Real-Time Video,≅ Proc. IEEE Workshop on Application of Computer Vision, pp.8-14, Oct 1998.

The optical zooming operation 34 of Fig. 2 provides a sufficient amount of zooming to ensure that a desired output image quality can be achieved, while also allowing for a certain amount of movement of the object of interest. The optical zooming operation 34 includes a framing portion with pan and tilt operations for framing the object of interest 22-*k*, followed by a zooming portion with a zooming operation that continues until designated stopping criteria are satisfied.

Assuming that the radial distortion of the camera lens is negligible, the following approach can be used to estimate the required amount of pan and tilt in the framing portion of operation 34. Suppose the object of interest 22-*k* is detected in operation 32 as being located at a pixel coordinate position (x, y) in image 42. The framing portion of operation 34 adjusts the pan and tilt of camera 18 such that the object of interest appears in the

center (c_x,c_y) of the image. Let ZF be the current zoom factor, α_P^C be the current camera pan angle, α_T^C be the current camera tilt angle, and D be the number of degrees per pixel, as predetermined when the camera zoom factor $ZF = 1$. The new pan angle α_P^N and new tilt angle α_T^N are then given by:

$$\alpha_P^N = \alpha_P^C + D*((x-c_x)/ZF),$$

$$\alpha_T^N = \alpha_T^C + D*((y-c_y)/ZF).$$

Other techniques may also be used to determine the appropriate pan and tilt adjustments for the framing portion of operation 34. For example, techniques for determining pan and tilt in the presence of radial distortion of the camera lens will be apparent to those skilled in the art.

After completion of the framing portion of operation 34, the zooming portion of operation 34 is commenced. As previously noted, this portion of operation 34 involves an optical zooming which continues until one or more designated stopping criteria are satisfied. There are a number of different types of stopping criteria which may be used. In a fixed stopping criteria approach, the optical zooming continues until the object of interest occupies a fixed percentage of the image. For example, in a video conferencing system, the optical zooming may continue until the head of the current speaker occupies between about 25% and 35% of the vertical size of the image. Of course, the specific percentages used will vary depending upon the tracking application. The specific percentages suitable for a particular application can be determined in a straightforward manner by those of ordinary skill in the art.

In a dynamic stopping criteria approach, the optical zooming again continues until the object of interest reaches a designated percentage of the image, but the percentage in this approach is a function of another detected quality associated with the object of interest. For example, the percentage may vary as a function of qualities such as level of apparent motion, use of particular key words or other audio or speech cues, change in intensity, pitch or other voice quality, etc. Again, the specific percentages and the manner in which they vary based on the detected qualities will generally depend upon the particular tracking application, and can be determined in a straightforward manner by those skilled in the art.

The result of the optical zooming operation 34 is an optically-zoomed image 44, in which the object of interest 22-*k* is centered within the image and occupies a desired

percentage of the image as determined based on the above-described fixed or dynamic stopping criteria. The image 44 may be stored by the system 10, e.g., in memory 14.

The virtual zooming operation 36 is then performed on the optically-zoomed image 44. This virtual zooming operation first extracts a region of interest from the image 44. For example, in the video conferencing application, a region of interest 47 may be identified as the head and shoulders of the current object of interest 22-*k*. In video surveillance applications, the region of interest may be the hands, feet, head, body or other designated portion of the object of interest. The identification of the region of interest may be a dynamic process, e.g., it may be selected by an operator based on the current tracking objectives. The region of interest may be identified and extracted using known techniques, e.g., the techniques described in the references cited above in conjunction with detection of the object of interest. The extracted region of interest is then interpolated using well-known image interpolation techniques to generate a video output which includes the virtually-zoomed image 46. The image 46 thus represents a virtual zoom of the optically-zoomed image 44.

It should be noted that the virtual zooming operation 36 may be performed in a different system than the detection and tracking operation 32 and optical zooming operation 34. For example, the image 44 may be compressed and then transmitted from the system 10 via the I/O device 15, with the virtual zooming operation being performed in signal processing elements of a corresponding receiver.

Advantageously, the hybrid mechanism 30 allows for a certain amount of movement on the part of the object of interest, while preserving a desired level of image quality in the video output. For example, if the object of interest 22-*k* moves, the virtual zooming operation 36 can be repeated using the same pan, tilt and zoom settings determined in the optical zooming operation 34. In this case, the extraction and interpolation operations of the virtual zoom can result in an output image in which the object of interest 22-*k* remains substantially centered in the image.

The hybrid mechanism 30 can incorporate multiple thresholds for determining when the virtual zooming and optical zooming operations should be repeated. For example, if a given amount of movement of the object of interest exceeds a first threshold, the virtual zooming operation 36 may be repeated with the pan, tilt and zoom settings of the camera unchanged. If the given amount of movement exceeds a second, higher threshold, the optical zooming step 34 may be repeated to determine new pan, tilt and zoom settings, and then the virtual zooming operation 36 is repeated to obtain the desired output image 46. A feedback path 48 is included between the optical zooming operation 34 and the detection and tracking

operation 32 such that the detection and tracking operation can be repeated if necessary, e.g., in the event that the optical zooming operation detects a substantial movement of the object of interest such that it can no longer track that object.

The hybrid optical and virtual zoom mechanism of the invention provides a number of significant advantages over conventional approaches. As described previously, the hybrid mechanism accommodates some movement of the object of interest without the need to determine new optical pan, tilt and zoom settings, while also providing a desired output image quality level. By preventing the PTZ camera from zooming in too far, the invention ensures that the PTZ camera settings are adjusted less frequently, and the computational load on the system processor is thereby reduced relative to that required by a conventional optical zoom approach. In addition, the hybrid mechanism of the invention can provide an improved compression rate for image transmission. For example, as noted above, the virtual zoom operation can be performed after an image is transmitted from the system 10 to a receiver via the I/O device 15. Consequently, the proportion of the object in the transmitted image is lower than it would otherwise be using a conventional approach, thereby allowing for less compression and an improved compression rate.

The above-described embodiment of the invention is intended to be illustrative only. For example, the invention can be used to implement real-time tracking of any desired object of interest, and in a wide variety of applications, including video conferencing systems, video surveillance systems, and other camera-based systems. In addition, although illustrated using a system with a single PTZ camera, the invention is also applicable to systems with multiple PTZ cameras, and to systems with other types and arrangements of image capture devices. Moreover, the invention can utilize many different types of techniques to detect and track an object of interest, and to extract and interpolate a region of interest. The invention can also be implemented at least in part in the form of one or more software programs which are stored on an electronic, magnetic or optical storage medium and executed by a processing device, e.g., by the processor 12 of system 10. These and numerous other embodiments within the scope of the following claims will be apparent to those skilled in the art.

CLAIMS:

1. A method for tracking an object of interest (22-*k*) in a video processing system (10), the method comprising the steps of:

detecting the object of interest in a first image (40) generated by a camera (18);

performing an optical zooming operation (34) to establish at least a zoom setting for the camera in accordance with one or more designated stopping criteria based on the object of interest; and

performing a virtual zooming operation (36) on a second image (44) generated by the camera at the established setting.

2. An apparatus for tracking an object of interest (22-*k*) in a video processing system (10), the apparatus comprising:

a camera (18); and

a processor (12) coupled to the camera and operative to detect the object of interest in a first image (40) generated by the camera, wherein the processor directs the performance of (i) an optical zooming operation (34) to establish at least a zoom setting for the camera in accordance with one or more designated stopping criteria based on the object of interest, and (ii) a virtual zooming operation (36) on a second image (44) generated by the camera at the established setting.

3. The apparatus of claim 2 wherein the camera is a pan-tilt-zoom (PTZ) camera having adjustable pan, tilt and zoom settings.

4. The apparatus of claim 3 wherein the optical zooming operation includes framing the object of interest by adjusting the pan and tilt settings of the camera, and performing an optical zoom on the framed object of interest until the designated stopping criteria is met.

5. The apparatus of claim 2 wherein the designated stopping criteria indicates that the optical zooming continues until the object of interest occupies a percentage of a resulting image.

6. The apparatus of claim 5 wherein the percentage is a fixed percentage.

7. The apparatus of claim 5 wherein the percentage varies as a function of a detected quality associated with the object of interest.

8. The apparatus of claim 7 wherein the detected quality associated with the object of interest includes at least one of a level of apparent motion, a use of a particular audibly-detectable cue, and a change in a voice quality.

9. The apparatus of claim 2 wherein the virtual zooming operation includes identifying a region of interest (47) in the second image, extracting the region of interest, and interpolating the extracted region of interest to generate a third image (46).

10. The apparatus of claim 3 wherein the processor is further operative to direct a repeating of the virtual zooming operation on the second image using pan, tilt and zoom settings established in the optical zooming operation if a level of movement of the object of interest exceeds a first threshold.

11. The apparatus of claim 10 wherein the processor is further operative to direct a repeating of the optical zooming operation in order to establish at least one new setting for the camera if the level of movement of the object of interest exceeds a second threshold higher than the first threshold.

12. The apparatus of claim 2 wherein the video processing system comprises a video conferencing system.

13. The apparatus of claim 2 wherein the video processing system comprises a video surveillance system.

14. An article of manufacture comprising a storage medium (14) for storing one or more programs which when executed by a processing system (10) implement the steps of:

detecting an object of interest (22-*k*) in a first image (40) generated by a camera (18);

performing an optical zooming operation (34) to establish at least a zoom setting for the camera in accordance with one or more designated stopping criteria based on the object of interest; and

performing a virtual zooming operation (36) on a second image (44) generated by the camera at the established setting.

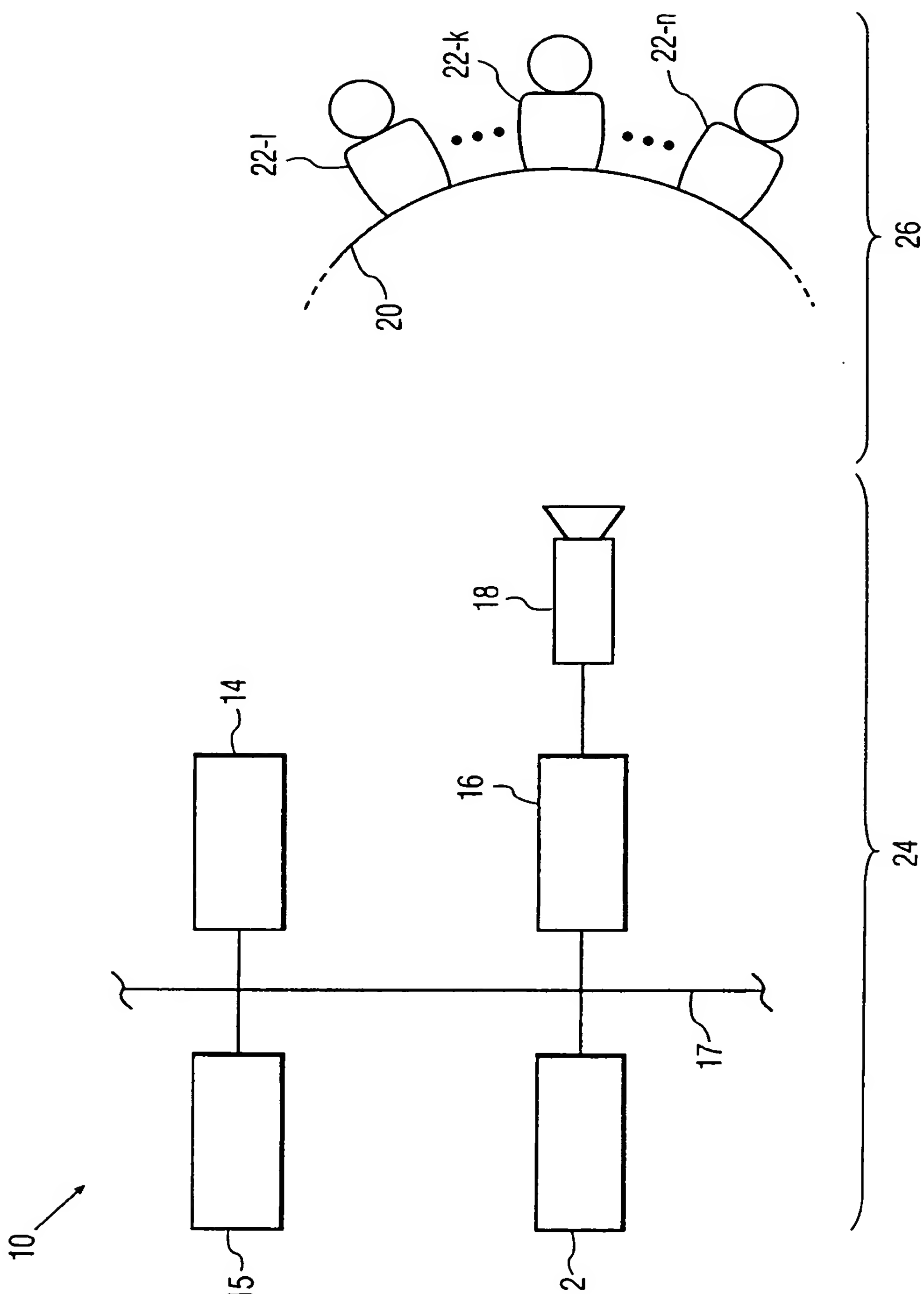

FIG. 1

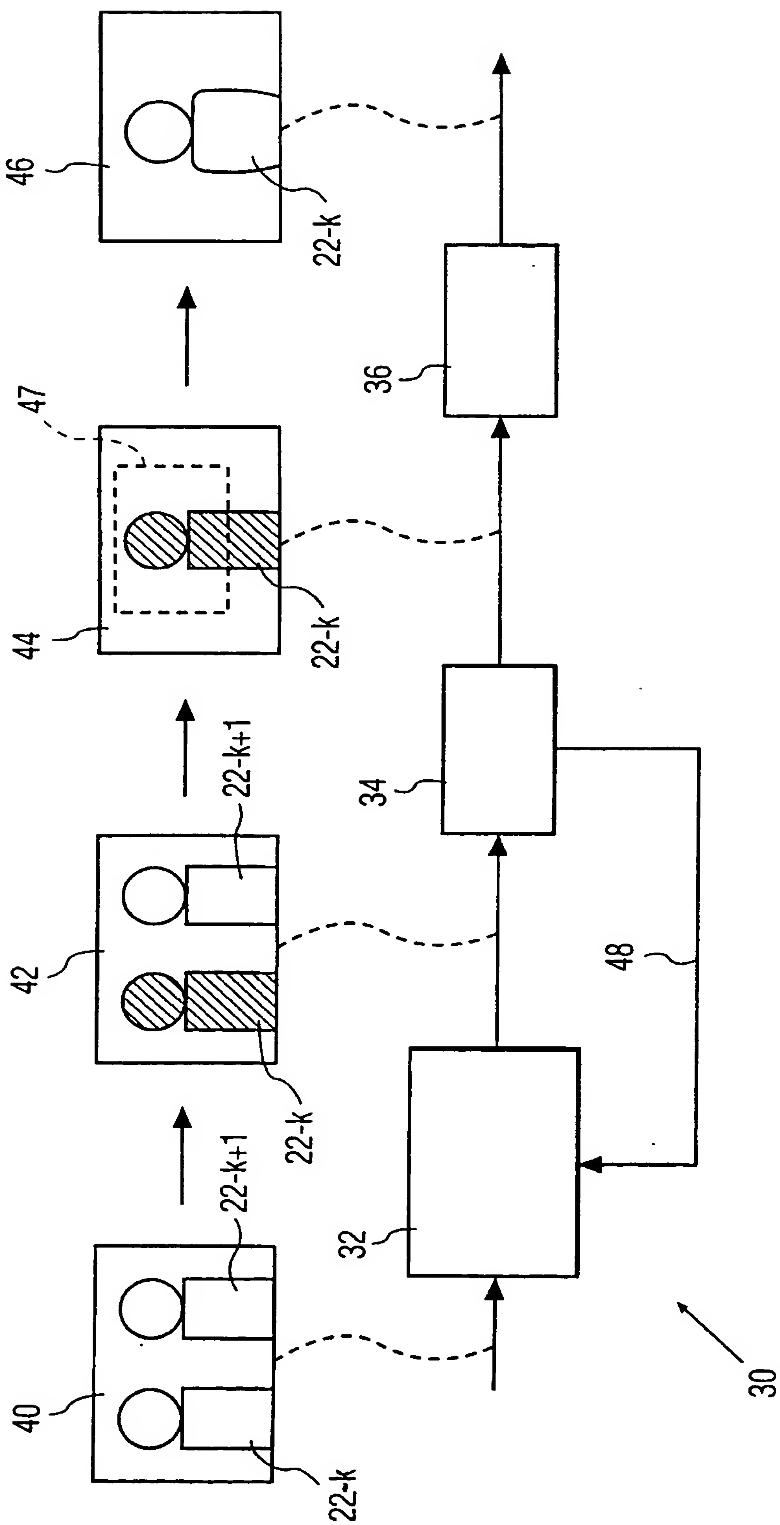

FIG. 2

INTERNATIONAL SEARCH REPORT

Intern. ,nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/15 G01S3/786

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, WPI Data, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 185 667 A (ZIMMERMANN STEVEN D) 9 February 1993 (1993-02-09) column 1, line 49 -column 2, line 59 column 3, line 25 - line 57; figure 1 column 4, line 48 -column 5, line 8; claim 1	1,2,9, 12-14
A	US 5 187 574 A (KOSEMURA KATSURA ET AL) 16 February 1993 (1993-02-16) cited in the application column 2, line 9 -column 3, line 38	1,2,14
A	US 5 200 818 A (NETA INBAL ET AL) 6 April 1993 (1993-04-06) column 2, line 15 -column 3, line 18; figure 1	1,2,14

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
21 November 2000	28/11/2000

Name and mailing address of the ISA	Authorized officer
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Inten ›nal Application No
PCT/EP 00/05951

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5185667 A	09-02-1993	EP 0539565 A	05-05-1993
		EP 0971540 A	12-01-2000
		JP 3051173 B	12-06-2000
		JP 6501585 T	17-02-1994
		US 5359363 A	25-10-1994
		US 5313306 A	17-05-1994
		WO 9221208 A	26-11-1992
		US 5384588 A	24-01-1995
		US 5903319 A	11-05-1999
		US 5990941 A	23-11-1999
		US RE36207 E	04-05-1999
		US 5764276 A	09-06-1998
		US 5877801 A	02-03-1999
US 5187574 A	16-02-1993	JP 2050313 C	10-05-1996
		JP 4104684 A	07-04-1992
		JP 7071288 B	31-07-1995
US 5200818 A	06-04-1993	NONE	